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A typical design for energy-efficient building:

A case study of zero energy building

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ABSTRACT

Recently, the consumption of energy in residential buildings has increased. On one hand, urbanization increased energy consumption in residential buildings. On the other hand, construction of nonstandard buildings especially residential buildings caused excessive energy waste. Implementation of energy efficiency and zero energy buildings strategies is one of the best solutions to decrease energy waste and energy intensity in a residential building in Kabul City. This research is conducted to design typical energy-efficient and zero energy building strategies for Kabul City. The majority of people use unrefined fossil fuels for heating. As we know, fossil fuels cause more environmental pollution. To burn these fuels, most GHGs emissions are released in the atmosphere, and these GHGs are very harmful to health and cause different types of illnesses. Our work is done in two stages. First, the construction cost of a normally built building is calculated. Then, the heat loss and heat gain of this inefficient building are also calculated. The same procedure is repeated for a more efficient and insulated building. After comparing, it is revealed that an insulated building saves 65% of the energy and emits 60% less CO_2 compared to the inefficient building. To make this building a zero energy building, we tried using photovoltaic technology. All-electric loads for this building were calculated and the components of the photovoltaic system were designed accordingly. In conclusion, the implementation of energy efficiency and zero energy has lots of benefits of cost-saving, being environment-friendly, reduced illness, and individual sustainability for each building.

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1. Introduction

Energy-efficient buildings are defined as buildings that are designed to provide the majority amount of reduction of the energy wanted for heating and cooling, severally of the energy and of the equipment which will be chosen to heat or cool the building. Energy is the infrastructure of our economic development and the quality of our lives. It is one of the most necessary topics of our time.

Worldwide greenhouse emissions increased by 70% between 1970 and 2004 because of great reliance on coal for electricity generation or oil for transportation. Still, around 1.2 billion citizens lack access to electricity, and around 2.8 billion citizens, mainly in our country and other developing countries of South Asia and Black Africa, depend on ancient clean biomass for baking and heating. Afghanistan, similar to other developing countries, is facing major energy challenges like low rates of access to fashionable energy services, insecurity of its energy provided due to a great reliance on imports, deforestation and health issues due to excessive use of fuel as primary energy supply, and pollution. With these issues in mind and considering the increasing demand for energy within the future, the major transition of the energy sector is required. Fortuitously, there are several opportunities to assist in this transition [1].

As a matter of fact, the majority of buildings in Afghanistan lack energy and power infrastructures. Likewise, most of the Afghan citizens struggle in providing basic needs. They remain cold in winter

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and also often experience indoor air pollution as a result of fuel consumption. Furthermore, it is stated that in 2013-2014, residential and commercial buildings in Afghanistan consumed about 74 % of the electrical energy supplied by DABS. As it was consumed for different purposes such as space heating, cooling, lighting, cooking, water heating, refrigeration, gadgets, and other human needs. Most of the developed countries improve their energy performance; citizens, companies, and municipalities need to know where there is scope for doing so. The first area of focus within the National Action Plan on Energy Efficiency is providing information and advice on energy efficiency. The second area of focus is promoting targeted investment in energy efficiency and doing this in innovative ways. The third principle behind the National Action Plan on Energy Efficiency is the demanding action: it is now mandatory for large companies to conduct energy audits. Similarly, new standards apply for new appliances and newly constructed buildings. Most of the measures requiring immediate action set out in the National Action Plan on Energy Efficiency have already been successfully implemented [2].

In many countries, buildings consume more energy than transport and industry. The International Energy Agency (IEA) statistics estimate that globally, the building sector is responsible for more electricity consumption than any other sector, 42 percent.

The efficiency of the appliances and equipment used in homes and businesses has increased greatly over the past decades. Available technologies in Afghanistan can provide an opportunity to improve the energy efficiency of already existing buildings. It should be possible to save from 30 to 50% of fuel used for heating, to lower energy bills and reduce CO_2 output [3].

Tables 1 and 2 show the impacts of insulation on heating energy demand and CO_2 emission reduction and its financial viability in two different climates in Afghanistan.

Table 1: Insulation impacts at climate zone in Afghanistan (central and North-east Afghanistan mountains).

Building space heated to 18 Degree Celsius	Heating needs (kWh/m2 of space/year)	CO2 emission reduction	Return on investment (years)
New building partially insulated, Day time use	95	49%	Less than one year
New building with improved insulated, Day time use	60	77%	2 to 3 years

Table 2: Insulation impact in continental climate zone in Afghanistan (out of mountains area, south-east and north-west plains).

Building space heated to 18 Degree Celsius	Heating needs (kWh/m2 of space/year)	CO2 emission reduction	Return on investment (years)
New building partially insulated, Day time use	65	48%	Less than one year
New building with improved insulated, Day time use	60	70%	3 to 4 years

Energy-efficient buildings can be defined as buildings that are designed to provide a significant reduction of the energy need for heating and cooling; therefore for heating and cooling they use efficient equipment and installed insulation materials with high U-Factors. With these solutions the reduction of energy losses will be prevented [4]. This can be achieved through the following elements.

2. Bioclimatic Architecture

Bioclimatic architecture takes into account climate and environmental conditions to help achieve thermal and visual comfort inside. The bioclimatic design takes into account the local climate to make the best possible use of solar energy and other environmental sources, rather than working against them. The bioclimatic design includes the following principles:

- The shape of the building has to be compact to reduce the surfaces in contact with the exterior. Interior spaces are laid out according to their heating requirements.
- Appropriate techniques are applied to the external envelope and its openings to protect the building from solar heat in winter as well as in summer; the building is protected from the summer sun, primarily by shading but also by the appropriate treatment of the building envelope use of reflective colors and surfaces.

3. High Performing Building Envelope

Thermal insulation is a low-cost, widely available, proven technology that begins saving energy, money, and reducing emissions at the moment it is installed.

Well installed insulation ensures energy efficiency in every part of the building envelope including ground decks, roofs lofts, walls, and facades. It is also well suited for pipes and boilers to reduce the energy loss of a building's technical installations. In cold regions, insulation keeps a building warm and limits the need for energy for heating, whereas in hot regions, the same insulation systems keep the heat out and reduce the need for air conditioning.

- An exterior wall is well insulated when its thermal resistance (R-value) is high, meaning the heat losses through it are small. Insulation is a key component of the wall to achieve a high R-value (or a low U value) for the complete wall. The thermal resistance R of the installed insulation products has to be as high as possible.
- To limit the thickness of the insulation within acceptable dimensions constantly improves the thermal conductivity of its materials, thus allowing increased thermal resistance within the same space.

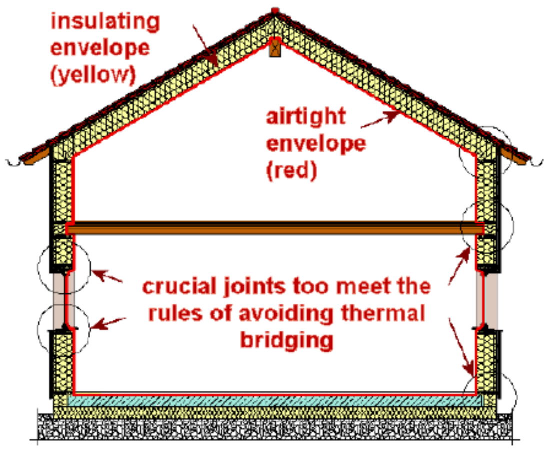

Figure 1. Sample of insulation materials [4].

4. Case study

The advantages of energy efficiency through a case study that implemented energy efficiency in buildings.

4.1. Case study: Energy-efficient health clinic in Afghanistan

Health clinics like other public buildings in Afghanistan are not built energy-efficient. They are very cold in the winter and hot in summer. These public buildings especially in rural areas do not have enough funding to purchase wood or other energy sources such as LPG or coal to heat their rooms. In the meantime, the majority of these clinics do not have electricity to power their fans or other means of cooling. For the first time, in 2008, GERES6 developed guidelines for energy-efficient clinics in Afghanistan and implemented its guidelines on a brand new health clinic in Sapahi Khil village, Gardiz, Paktia province. The health clinic is a single-story building with a total floor surface of 280 m^2 operating only during the day.

Figure 2. Health clinic in Sapahi Khil village, Paktia.

Some of the major energy efficiency measures include the following:

- The largest face of the building faces south with a major overhang (50 cm).
- Roofs are insulated using glass wool.
- Walls are double brick and insulated with 5 cm polystyrene.
- Foundation is insulated using 3 cm insulation.
- Windows are wooden with double glazing.
- The building is heated using Bukharis and gas stoves.

The total estimated cost of the building including the implementation of the energy efficiency measures was USD 90,000. Insulation cost was USD 20.5/m^2.

Nowadays, most of the buildings in Kabul City are built with low quality as well as lower initial prices. Most of the maps are being adopted in foreign countries and people are willing to use them, because of their lower prices without considering the field specifications like temperature, humidity, shading orientation, geographical location, and so on. Also, construction companies try to finish their work as cheaper as possible; their aims are just to design a cost-effective project. Thus, they do not even think the annual cost of energy will be used for heating and cooling for buildings. In addition, the biggest problem of Kabul citizens is bulk emissions of toxin gases outside which spread by fossil fuels to keep the comfortable temperature indoor, especially in winter. As we know, the majority of Kabul citizens used fossil fuels for heating especially coal. It is clear that the burning of fossil fuels has too many bad effects on the environment and health. During the winter, the weather of Kabul City becomes worst, and most people get sick to breath toxin gases. If this situation continues like this, most Kabul citizens face lung cancer. One of the efficient methods to reduce the amount of fossil fuels is the implementation of energy efficiency in buildings and zero energy buildings. Therefore, to address the aforementioned challenges facing Kabul citizens, this research has been conducted on energy efficiency and zero energy buildings.

5. Problem Statement

Environment issue is a global problem, so all countries face this challenge. Developed countries made different ways to keep their environment clean by some feasible methods, but developing countries and underdeveloped countries do not have certain ways to keep their environment clean. One of the important things is an economic issue that underdeveloped countries and developing countries are not able to overcome. Unfortunately, Afghanistan is one of the underdeveloped countries that is facing too many environmental problems, and it is increasing day by day. The poor economy of Afghan is the main cause of the problem of environmental pollution, and people are not able to purchase high-quality materials especially for heating. Most people used coal and other materials to spread lots of toxin gases for heating their houses, and these gases are released into the atmosphere. So, it has, directly and indirectly, health effects. In addition, most of the electric energy of Afghanistan is imported and comes from neighbor countries, and it has a dependency on power. The best method that should decrease the dependence of energy and keep the environment clean is to decrease GHGs, prevent energy loss, and eliminate the dependency of power.

6. Proposed solution mechanism

To reduce greenhouse gases and have a sustainable energy in Kabul City, this research is done. Recently, the thickness of the exterior wall in the building is not standard. If a building is constructed, it should be built with wide thickness because the thickness of the exterior wall has direct effects on heat loss and heat gain. Also, putting insulation materials in exterior walls has more advantages. These materials increase the resistivity of heat and do not allow heat to exist in the building in winter. Moreover, these materials barricade the external heat to come in the building by conduction in the summer. In addition, renewable energy use makes a sustainable building, because the electricity of Kabul City is not sustainable. This mechanism can help to have sustainable energy. As we know, Afghanistan has enough renewable energy sources especially solar energy, so the installation of a photovoltaic system is the best solution to access electric energy. Therefore, energy-efficient and zero energy buildings can be designed to have green and sustainable energy in Kabul City.

7. Methodology

A typical map of a residential building that has three floors, 18 rooms, and one basement built on 240 m^2 is considered. This research is designed in two terms. Term one: Inefficient and Nonzero Energy Building, where all the components of the building are estimated with common materials which the majority of buildings have. The estimation of the building is divided into four categories. First, mobilization and demobilization which start the project. The cost of this activity depends on the salary of laborers and the cost of equipment. Second, all construction work starts from excavation up to painting depending on civil work. Third, the entire electric work is estimated in this part. Next, all expenditures on water supply and sanitation work are estimated in this part. For design and its cost analysis, the total cost of construction is estimated. This estimation consists of material cost based on the number of activities calculated by m^3, and some of them are estimated by m^2.

Table 3: Construction cost of the building.

No.	Activity	AFN	USD
1	Subtotal for Mobilization and Demobilization	50,000	650
2	Subtotal for Main Building Civil Works	14,303,167	185,755
3	Subtotal for Water Supply and Sanitation Works	496,783	6,452
4	Subtotal for Electrical Works	414,134	5,378
Total		15,264,084	198,235

8. Energy Efficiency

Conferring to different research, the weather of Kabul sometimes downtrends from -5 degrees Celsius in winter [5] and humans feel comfort in 21 degrees Celsius. So, the difference between outdoor and indoor temperatures is high. According to heat transfer, heat always transfers from high to low, and this is a conduction type of heat transfer between the atmosphere outside and inside the building. Cold weather comes from outside into the inside with infiltration mechanism by walls gap, windows gap, and glasses gap.

According to calculations, the amount of heat loss, heat gain, and HVAC system keeps the constant temperature of the indoors which is calculated in Table 4. This estimation depends on the U-Factor of walls, windows, doors, floor, and roof. Table 4 shows the U-Factor of different components.

Table 4: Calculation of U-factor in phase 1 [6].

Description	Material	Thermal conductivity	Thickness	Resistivity	U- Factor
Wall	Brick	0.8	0.35	0.4375	2.049159
	Plaster + Gypsum	0.99	0.05	0.0505051	
Window	PVC				1.3
Door	Wood				2.3
Floor	Concrete	1.43	0.5	0.3496503	2.309556
	Soil	2.4	0.2	0.0833333	
Roof	Concrete	1.43	0.15	0.1048951	3.851234
	Soil	2.4	0.2	0.0833333	
	Gravel	1.4	0.1	0.0714286	

If the owner of the building wants to use fossil fuels for heating, they stand out to know how much fuel is needed to keep the air quality comfortable. Using fossil fuels for heating among Kabul citizens is surveyed and the survey is shown in Figure 2. This survey shows that the purchasing cost of these fuels became 188,577 AFN/Year. Also, the amount of CO^2 emitted from these fuels and spread in the atmosphere is 5309.856 Kg/Year. The cost of fuels and CO^2 emissions is very high. In this section with the previous materials, polystyrene insulation is added in external walls, floors, and roofs. Insulation materials increase heat resistivity [6], and it prevents the heat from getting out. The below table shows the U-Factor of different components inclusive of insulation material.

Table 5: Calculation of U-factor in phase 2 [6].

Description	Materials	Thermal conductivity	Thickness	Resistivity	U- Factor
Wall	Brick	0.8	0.35	0.4375	0.233209
	Plaster + Gypsum	0.99	0.05	0.0505051	
	polystyrene	-	0.01	3.8	
Window	PVC				1.3
Door	Wood				2.3
Floor	Concrete (RCC)	1.43	0.35	0.2447552	0.220728
	polystyrene	-	0.15	4.2857143	
	Plaster	0.8	0.05	0.0625	
Roof	Concrete	1.43	0.15	0.1048951	0.170174
	polystyrene	-	0.2	5.7142857	
	Waterproof	0.35	0.02	0.0571429	

After installation of insulation materials, the amount of heat loss and heat gain decreased. Also, the power consumption of the HVAC system [4], the cost of fossil fuels, and CO^2 emissions decrease. This material is the best solution to decrease heat loss and heat gain and decrease CO^2 emissions. Table 6 shows the impact of insulation material on each side.

Table 6: Several differences between inefficient and efficient buildings.

Inefficient building				Efficient building			
Heat loss		Heat gain		Heat loss		Heat gain	
Conduction (kW)	73,093.46	Conduction (kW)	37,779.84	Conduction (kW)	11,989.70	Conduction (kW)	6,482.72
Infiltration (kW)	16,004.50	Infiltration (kW)	8,002.25	Infiltration (kW)	16,004.50	Infiltration (kW)	8,002.25
Total (kW)	89,097.96	Solar Radiation	3893.214	Total (kW)	27,994.20	Solar Radiation	3893.214
		Total (kW)	49,675.31			Total (kW)	18,378.19
Power of HVAC system (kW)			26	Power of HVAC system (kW)			14
Annual cost of resource for heating			CO_2 emission Kg/year	Annual cost of resource for heating			CO_2 emission Kg/ year
Wood (AFN)		36,612	463.752	Wood (AFN)		11,934	151.164
Coal (AFN)		16,920	4842.504	Coal (AFN)		5,328	1,524.8736
Gas (AFN)		99,000	3.6	Gas (AFN)		30,937.5	1.125
Electricity (AFN)		36,045	0	Electricity (AFN)		11,340	0
Total (AFN)		188,577	5309.856	Total (AFN)		59,540	1,677.1626

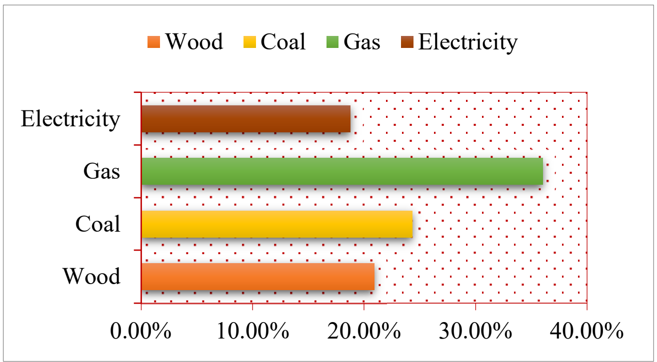

Figure 3. Percentage of kabul citizen's use for heat.

9. Zero energy building:

A zero energy building (ZEB) produces enough renewable energy to satisfy its own annual energy consumption needs, thereby reducing the utilization of nonrenewable energy within the building sector. ZEBs use all cost-efficient measures to decrease energy usage through energy efficiency and consist of renewable energy systems that manufacture enough energy to fulfill remaining energy wants [7]. There are a number of long-term advantages of moving toward ZEBs, including lower environmental impacts, lower operating and maintenance costs, better resiliency to power outages, and improved energy security. In zero energy building, all appliances and HVAC systems feed with photovoltaic systems. The connection of the photovoltaic system is grid-tie in which all systems are designed in PVSyst software. This software needs to know the power consumption of all electrical equipment such as lighting, TVs, motors, and other things. The total power consumption of appliances according to the electric scheme is 25KVA = 20KW.

Table 7: Specification of PV system.

Specification of PV design			Inverter specification		
PV Module			DC input parameters	Value	Unit
Plant capacity	kW	20 DC	Max. Input Power	13000	Wp
Module capacity	Wp	300	Max. Input Voltage	1000	V DC
Total Modules	Nos.	72	MPPT Operating Voltage Range	480-800	V DC
Nominal power	kWp	21.6	Max. Input current per MPPT Tracker	13	A
Operating condition	kWp	19.3	MPPT Channel	2	-
Module area	m²	140	Number of input	2	-
Inverter			AC output parameters	Value	Unit
Nominal power	kWac	10	Max. Output Power	10000	Watt
No. of inverter	Nos.	2	Rated output power	1000	Watt
Total Power	kWac	20	Main output voltage range	320-480	V AC
Operating Voltage	V	750	Rated output current	15	A
Cost			Main output frequency range	45-55	Hertz
Energy cost	$/kWh	0.04	Cost	621	$
Total cost	$/Wp	0.71	Number of Inverter	2	Pcs
Produced Energy	MWh/Year	38.65	Total Cost	1242	$
Running cost	$/ Year	300	Module specification		
			Manufacture	Yingli Solar	
DC Cable specification			Cell Technology	Poly Crystalline	
Types	XLPE Copper		Module capacity	WP	300
Current	8.27	A	Vmpp	V	36.27
Diameter	4	mm	Voc	V	45.27
Length	140	m	Impp	A	8.271
Cost	120	AFN/m	Isc	A	8.837
			Length	m	2
			Width	m	1
			Area	m²	2
			Cost	$/W	0.6

10. PV design for HVAC system

The total HVAC system power consumption is 14 kW after adding insulation materials. As calculated above the price of each watt of the system was found to be 0.71 $ and for the same price, the calculation is done. To decrease the initial cost of the PV system, this paper performs a designed on-grid system. During the night, all electrical equipment in the building feeds by a grid because batteries are very expensive and the lifetime of these components is short.

10.1. On-grid inverter

A grid-tie inverter converts direct current (DC) into alternating current (AC) suitable for injecting into an electrical power grid. Grid-tie inverters are used between local electrical power generators such as solar panels, wind turbines, hydropower, and the grid. To inject electrical power efficiently and safely into the grid, grid-tie inverters must accurately match the voltage and phase of the grid sine wave AC waveform.

10.2. Smart meter

A smart meter is an electronic device that records consumption of electric energy and communicates the information to the electricity supplier for monitoring and billing. Smart meters typically record energy hourly or more frequently and report at least daily. To sell electricity over the network or to buy electricity from the network, a smart meter must be installed.

Table 8: Specification of smart meter.

Type	Unit	3 Phase
Current	A	200
Frequency	Hz	50-60
Voltage	V	120-480
Price	$/PCS	600
No.	PCS	4
Total price	$	2400

PVSyst simulation estimated the cost of photovoltaic to be 0.71 $/Watt. The total energy generated by the 20 KW PV system is 38.648 MWh/year, and the amount of energy generation of 14 KW HVAC system is 19.32MWh/year. The total amount of energy generated by the photovoltaic system is 57.968 MWh/year. The price of energy in a residential building in Kabul City is 3 AFN/kWh, so the cost-saving of the photovoltaic system is 155,904 AFN/year. The lifetime of the PV system is 25 years, and the lifetime cost-saving of the system is 3,897,600 AFN.

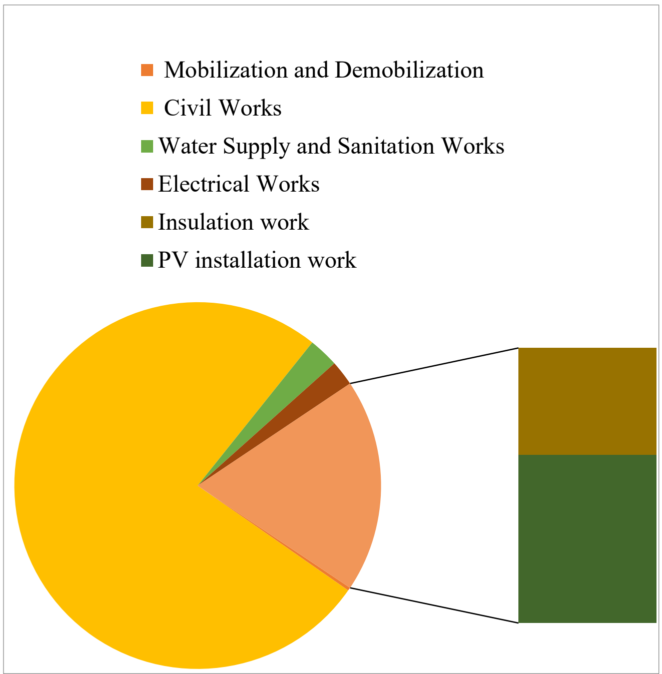

Figure 4. Percentage cost of each activity.

The below calculation shows the payback period of two types of implementation work. According to calculation, energy efficiency and zero energy building are acceptable in terms of cost-saving and environmental benefit.

Initial cost of insulation = 1,382,363.2 AFN

Yearly saving (Heating) = 129,037 AFN

Yearly saving (Painting) = 41,275 AFN

$$\frac{\text{Initial cost}}{\text{Cost-saving}} = \text{Payback period(Year)}$$

$$\frac{1,382,363.2}{129,037+41275} = 8.11 \text{ years} \quad = \text{Payback period of insulation material (Year)}$$

$$\frac{\text{Initial cost}}{\text{Cost-saving-Operating cost}} = \text{Payback period of PV system (Year)}$$

Initial cost of PV system = 2,160,150 AFN

Yearly cost-saving of PV system = 155,904 AFN

Operating cost = 0 (in design considered)

$$\frac{(2,160,150\,)}{(155,904)-(0)} = 13.8 \text{ years} \quad = \text{Payback period (Year)}$$

11. Results and discussion

The result demonstrates two important things: first, the advantage of energy efficiency in residential building, energy-saving, and cost-saving due to the implementation of energy efficiency. Also, energy efficiency can reduce significant GHGs emissions. A building with the same dimension can generate about 59 Kg/day CO_2 in winter, but when energy efficiency is applied, the amount of CO_2 decreases about 19 Kg/day. The insulation materials are not very expensive. It only costs 7.34 % of the whole cost of the building. Second, the advantage of a photovoltaic system is to have sustainable and secure energy. It is clear which renewable energy has more effect on the independence of a country. So for this building, the photovoltaic system was designed to generate electric energy. The total cost of the photovoltaic system is 11.52 % of the entire cost of the building. The cost of the photovoltaic system is higher, but at certain times can achieve their cost.

Based on common materials, the cost of a typical building was obtained. Next, the amount of heat loss and heat gain was found. These losses are natural, but it is controllable by some methods to keep air quality in the building. Also, the total cost of fossil fuels was estimated both in the inefficient and efficient buildings according to the usage of Kabul citizens. Moreover, the amount of CO_2 emissions emitted by fossil fuels was calculated. This toxin gas is very dangerous for health and the environment. If an inefficient building generates too much CO_2, the environmental pollution of a hundred buildings is very worrying. In addition, the capacity of solar systems is designed with all components both for electric appliances and the HVAC system. This capacity is divided into two parts because some citizens do not want to use an HVAC system for the whole building. Also, the available area for the photovoltaic system is not enough, so the owner of the building has to install a PV system in the ground.

12. Economic feasibility

Economic feasibility is an important factor for all projects. In this project, the amount of money that should be spent on energy efficiency is cost-effective. As was shown, the amount of cost which depends on insulation material is only 7.34% of all the project cost and it is feasible. For zero energy, the implementation cost does not exceed 11.52% of all the project cost. Therefore, we would like to say that this project is feasible in terms of economy.

13. Technological feasibility

For the implementation of this project in Kabul City, there is no problem finding polystyrene insulation material and photovoltaic equipment. So, it has technological feasibility.

14. Environmental feasibility

The part of environmental feasibility does not have a problem due to climate. Also, it has more advantages for the environment that are previously mentioned.

15. Field feasibility

There is no problem in using the insulation materials, but the installation of photovoltaic panels is a challenge. Available roof area for installing PV modules is 240 m^2, but this area is available to install 60 pcs PV module through 4 m distance between each row. The total PV modules which are designed are about 122 pcs, and they need more areas to install all of them. Thus, the field feasibility for zero energy building is not acceptable and needs to install PV modules in the ground.

16. Conclusion

As mentioned, the majority of buildings in Kabul City are not standard, and their annual energy consumption is very high. According to the survey, most of Kabul citizens used fossil fuels for heating in winter, so these fossil fuels generate toxic gases in the atmosphere. As we know, these gases have negative effects on the environment, health, agriculture, and groundwater. Therefore, this research is designed for a typical building which is located in Kabul City, and the design is divided into two categories. First, all activities are considered for inefficient buildings without any materials to increase heat resistivity.

Amount of heat loss and heat gain is calculated and the HVAC system is also selected. Then the annual cost of fossil fuels was calculated for those who do not want to install the HVAC system. These fossil fuels generate greenhouse gases, so the amount of CO_2 emitted was obtained. Carbon dioxide emissions indicate that the main cause of environmental pollution is fossil fuels to heat buildings. Second, insulation material in external walls, floor, and roof are added. When these suggested recommendations of EE implemented, more than 65% of energy and more than 60% CO_2 emissions are saved. To make zero energy building, we can use photovoltaic technology. All-electric loads and components of the photovoltaic system were calculated. The initial cost of this technology is higher, but annual energy production is significant. Also, these technologies are friendly to the environment. To have indoor comfortable temperature in the building in winter and summer, we should change from fossil fuels to the HVAC system. To sum up, the implementation of energy efficiency and zero energy has many benefits, such as cost-saving, environment-friendly, reduced illness, and having individual sustainability for each building.

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